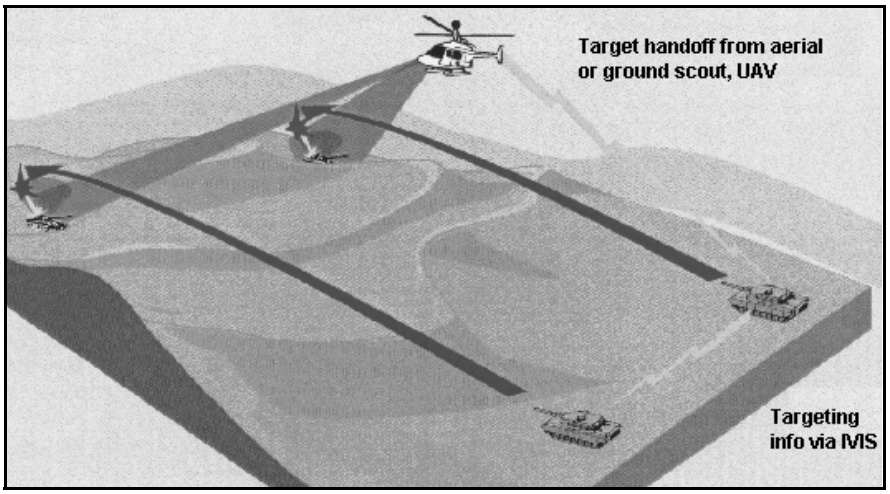
GDLS Photo

Tomorrow's Smart Tank Munitions

by Major Bruce J. Held

Tankers behold! The era of 'smart' tank munitions is approaching and your days of being referred to as DATs or dumb a–– tankers are rapidly closing. Over the next several years, new types of 'smart' tank ammunition will be fielded that not only have a terrific knockout punch, but also have an electronic brain to seek out targets and deliver the punch. With the fielding of these 'smart' rounds, tankers will be able to shoot bullets that do more than fly in ignorant, supersonic bliss to their appointment with destiny. Instead, 'smart' tank ammunition of tomorrow will search for and acquire targets, maneuver toward their targets, and then strike with devastating accuracy and lethality.



Concept drawing shows aerial scout handoff to STAFF-equipped tanks on a digital battlefield.

The tactical implications of 'smart' tank munitions are complex and extensive, therefore we must start to energetically explore and experiment with our new opportunities. The tactics, techniques, and procedures needed to employ these new weapons effectively must be developed and in place **before** units begin placing 'smart' tank rounds in their basic loads. Thus, the purpose of this article is to energize the Armor community to begin a critical analysis of the tactical use of 'smart' tank munitions. To accomplish this, we will begin by discussing the key elements of 'smart' tank munitions and how these new weapons bring tactical value to the battlefield. To activate the Armor community's creative mind, we will end by describing several potential scenarios in which 'smart' tank munitions could have a significant impact.

What Makes a Round 'Smart'?

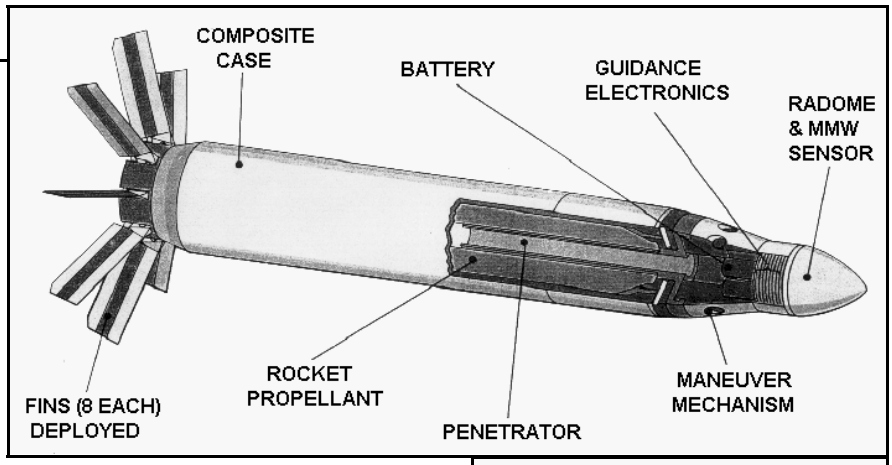
'Smart' tank munitions must possess four key capabilities including: target acquisition, target identification and selection, maneuver control, and a lethal mechanism. These capabilities can be enhanced by a nearly unlimited number of options. The goal, however, is to limit the components so that everything needed will fit within the cartridge and within a reasonable budget. With this in mind, we feel that the four capabilities identified above are the minimum requirements for future 'smart' munitions.

First of all, 'smart' munitions require a target acquisition capability, which is either passive or active. Passive target acquisition relies on emissions of some sort emanating from the target and being detected by the round. These types of emissions include optical, thermal, and magnetic energy. Active target acquisition relies on painting the target

with some form of energy and detecting the reflection of that energy. Ammunition developers consider radar and ladar (reflected laser energy) as the most likely forms of active detection that will find their way into ammunition or fire control systems. The type of acquisition system selected depends on target characteristics, desired capabilities for the munitions and the environment in which it is to be used. In some cases, more than one type of target acquisition sensor may be required.

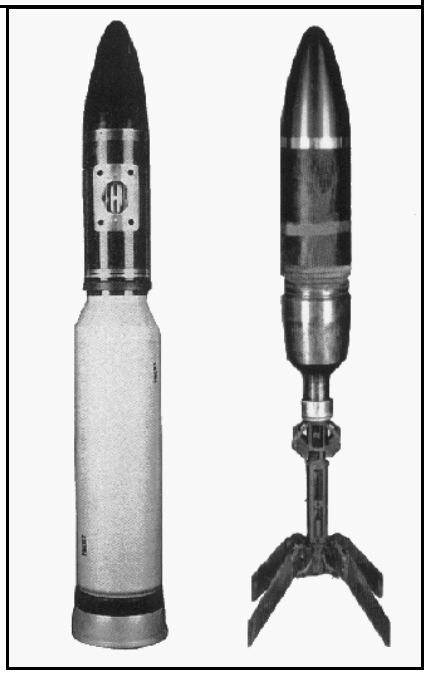
Secondly, 'smart' tank munitions require the ability to conduct target identification and selection. They must be able to distinguish real targets from battlefield clutter. For example, if a 'smart' munition uses a thermal sensor for target identification, the electronics that read the sensor inputs must be able to distinguish, with high reliability, between all the various heat sources on the battlefield. This means that great care must be taken to ensure that the round's sensor does not just identify the hottest spots on the battlefield as targets. The acquisition method used must also be robust; i.e., resistant to countermeasures. A 'smart' munition is useless if it can be easily fooled by the enemy. Creating this capability is not an easy proposition. To the human viewer, with his very complex pattern recognition ability, the thermal signature from a burning tank or a countermeasure flare is relatively easy to distinguish from a tank that is still a dangerous target. Size and cost limitations, however, force the electronic brains of a 'smart' round to be relatively simple; normally only a few microchips. Electronics engineers and programmers must figure out how to make the round 'smart enough' within the limited electronics package that can be carried.

Third, 'smart' tank munitions must maneuver their lethal mechanism to its intended target. As with target acquisition, this is not an easy task. In order to maneuver to a target, the round needs to 'know' its own position, what its dynamic state is, where the target is, and what the dynamic state of the target is. The round also needs some form of maneuver mechanism, the physics of which must be encoded into its electronic brain. Maneuver mechanisms generally fall into one of two types. One type uses aerodynamic control surfaces, such as tail fins and canards, to guide the round onto a new line of flight. The other type uses rocket thrusters to change the direction of flight. It is also possible to employ hybrid types that use both control surfaces and rockets to turn the round. Whatever type of maneuver mechanism is employed, it must be strong, yet very precise. Tanks shoot in a direct fire mode. This means that the rounds fly at speeds of thousands of feet per second. As a result, the round has a great deal of momentum. Trying to change the direction of a heavy projectile that is traveling so fast requires a very strong mechanism. The speed of the projectile also implies that the time available to make a course correction is very short. A responsive, precise maneuver mechanism is required to make such a quick course correction towards a point target.



Above, the X-Rod round, fins deployed as in flight. It is a rocket-propelled, long rod penetrator that kills targets with kinetic energy, like the current sabot round.

At right, the XM943 top-attack smart round, which kills with a downward-firing explosively formed penetrator (EFP) that attacks the thinner roof and top deck of tanks.



Most importantly, the 'smart' tank munition's lethal mechanism must defeat the intended target. For the foreseeable future, the primary target of the U.S. Armor Force will continue to be other tanks. This means that the lethal mechanism must be able to penetrate a variety of armor types: homogeneous steel, composites, and explosive reactive armors. The real trick is to come up with a means of defeating targets that employ these armor types in combination. Pending some new development, the ability to penetrate these armors will depend on the current penetration technology triad that includes long rods, explosively formed penetrators (EFP), and shaped charges.

Finally, we must also discuss the most difficult task of all, systems integration. All the various parts of the 'smart' munition must be packaged into a space small enough to fit into a 105- or 120-mm cartridge. To make things even more difficult, all the parts and assemblies must be hardened to survive the violent, high g launch from a tank cannon. Finally, all the miniaturized, hardened, disparate parts of the round must be able to function perfectly, as an integrated whole, in a tactical environment, after sitting for years in storage.

Two examples of 'smart' tank munitions are the 120-mm Smart, Target Activated, Fire and Forget (STAFF) and the X-Rod. STAFF, currently in Engineering and Manufacturing Development, combines the four attributes described above. It has a radar seeker that scans the line of flight for targets and software that helps it discriminate potential targets from battlefield clutter

and countermeasures. Once a target is found, the electronic brain of the STAFF rolls its warhead so that the EFP aligns with the target. It then times the firing of the EFP to achieve center-of-target impacts. A big advantage of STAFF is that once fired, the tank crew can move on to other targets; the round's electronic brain and target seeker work autonomously. Additionally, since the EFP has a top-attack capability, the STAFF is able to defeat both partially and fully defiladed targets.

X-Rod, which is now going through proof-of-principle testing, will also carry its own target seeker and electronics, so in the basic sense, it will be a fire-and-forget weapon like STAFF. Unlike STAFF, X-Rod will rely on rocket thrusters for maneuver. A large rocket motor will also boost a long rod penetrator to high speed. Additionally, whereas STAFF is a top-attack munition, X-Rod penetrates the front and sides of targets, much like traditional KE ammunition. X-Rod's advantage will lie in its ability to steer a long rod penetrator, thus making it ideal for attacking maneuvering armored targets.

Is There Value in Developing 'Smart' Tank Munitions?

There are many unknowns in the development of 'smart' tank munitions. One thing is certain, however. The price tag for a 'smart' tank round will be greater than for a traditional KE or HEAT round. Several key questions thus arise, to include: what is the tactical value of this expensive round of ammunition, is it cost effective, and isn't what we have now good enough? We must consider several factors to answer these questions. First we must consider the development of threats against the U.S. Armor Force. Next, we need to determine how we want to meet those threats. And finally, we must consider cost, not just for each individual round, but the total cost effectiveness of defeating an enemy with 'smart' ammunition in the basic load.

Despite the end of the Cold War, defense technologies are still being developed around the world. Most significantly for U.S. tankers, work continues in many countries on tanks and attack helicopters. For the most part, this work is aimed at improving existing systems, but completely new systems are also being developed and deployed. Examples such as the Russian Havoc or the Western European Eurocopter indicate that there is still interest in fielding new antitank helicopter capability, while the French LeClerc and the T90 bring dangerous new capabilities to tank fleets around the world. In this era of reduced defense spending, much of the world's defense industry is shopping for new markets. No longer can we be confident that the weapons we will face on future battlefields will be of Soviet design; nor can we be certain that threat weapons of Western design will be obsolete. Instead, the U.S. Armor Force must be prepared to face the best Western designs, possibly including new U.S. designs. The conclusion here is that we cannot rest on our laurels. Continuous improvements in the lethality of the U.S. Armor Force are an absolute necessity if we are to defeat the new threats being developed and deployed.

Tank lethality development is concentrated into several areas, including target acquisition (finding targets), accuracy (hitting targets), and lethal mechanism (defeating targets). Improving the lethality of a tank involves improving one or more of these variables. Accuracy can be greatly improved by 'smart' tank munitions and the combat effectiveness of the U.S. tank fleet can be dramatically increased by exploiting this. For the foreseeable future, primary target acquisition will continue to be accomplished with sensors on board the tank. In special situations, however, 'smart' tank munitions may be able to enhance the overall acquisition capability of the total tank system. Finally, though current and contemplated lethal mechanisms can be flown with either 'smart' or traditional rounds, their effectiveness is increased with the improved accuracy of 'smart' tank munitions.

What do accuracy improvements mean in terms of the class of targets that can be attacked with 'smart' tank munitions? All targets currently engaged with traditional rounds should be vulnerable. In addition, 'smart' tank munitions can be expected to greatly improve the effective range of tank cannons. The range of current tanks is limited by the inherent dispersion of their shot pattern. The linear size of the dispersion pattern grows with range, so that at long range the chance of hitting a target is diminished. With some 'smart' rounds, the in-flight correction reduces the size of the dispersion pattern, making it nearly constant over a very long range. Other types of 'smart' tank munitions merely need to get close enough to the target to launch a lethal submunition, thus making the dispersion of the shot pattern less meaningful. In either case, 'smart' tank munitions should be expected to add 1 to 2 kilometers to the effective range of current tanks. In fact, a 'smart' tank munition's range is primarily limited to the distance the round can be fired or the maximum range at which targets can be acquired and identified.

An area that has always been a problem for traditional ammunition has been firing against defiladed targets. The presented area of the target is either small, making hit probability low, or completely masked, making it impossible. 'Smart' tank munitions will change this situation. Their greater accuracy will improve the probability of hitting the small presented area of hull-defiladed targets. Use of top-attack lethal mechanisms, such as EFPs, combined with the brain of a 'smart' tank munition make the top of the target vulnerable and allow engagements against even turret-defiladed targets.

The improved accuracy of 'smart' tank munitions provides obvious value. Having them in the basic load of a tank opens up the battlefield in terms of both space and time. Providing the tanker the ability to hit long range and defiladed targets expands the amount of territory that can be controlled by fire. This, in turn, improves the commander's decision cycle, providing him more time to react. It also hurts the enemy by reducing his decision cycle time, forcing hasty reactions on his part.

Traditional tank munitions also have problems against maneuvering targets, especially from medium to long range. KE ammunition takes more than a second to fly to 2000 meters. At 3000 meters and beyond, the time of flight can go to two or more seconds. A target traveling at only 20 miles per hour moves 30 feet in only one second. If this motion is at a constant speed and in a constant direction, a modern fire control system can correct for it. Unfortunately, most targets do not move in this manner. They tend to speed up, slow down and turn. When these maneuvers occur after the round is fired, the target may move off of the round's line of flight and avoid being hit. A 'smart' munition accounts for target maneuvers by correcting its line of flight near the target, or by launching a submunition while flying near the target. As a result, the 'smart' tank muni-

tion will be much more accurate against maneuvering targets.

In addition to improving accuracy against maneuvering targets, 'smart' tank munitions hold the promise of greatly improving our capability to fire on the move. With traditional tank ammunition, fire-on-the-move capability is significantly less than firing from a stationary tank, even with modern stabilization systems. There are a host of dynamic errors, such as gun tube vibration, that even sophisticated stabilization systems cannot correct. 'Smart' tank munitions make most of those errors irrelevant because they correct their own line of flight after leaving all the moving tank errors behind.

The ability to fire against evasive, maneuvering targets helps to destroy the operational tempo of enemy maneuver. Conversely, the ability to accurately fire from a maneuvering tank helps us increase the tempo of our own maneuver. Either way, the improved accuracy of 'smart' tank munitions improves our ability to fight highly dynamic battles, which can be instrumental in achieving tactical victory with minimal loss.

'Smart' tank munitions could also be an important part of the digital battlefield. We have already noted the ability of 'smart' tank munitions to maneuver or be top-attack weapons. This means that a direct line of sight between the firing tank and the target is not essential. An information system, such as the Intervehicular Information System (IVIS), could possibly be used to pass target locations from a remote platform, such as a helicopter, another tank, or a remotely piloted vehicle, to a firing tank. A 'smart' tank munition could then be launched toward the grid that was passed, even though the firing tank never identified the target itself. If used in this manner, 'smart' tank munitions give the Armor Force a very powerful tool on the digital battlefield.

Another type of engagement should be explored. Since a 'smart' tank munition will carry its own target acquisition, there is a possibility for reconnaissance by main gun fire. A 'smart' munition could be fired toward suspected, but unconfirmed enemy locations; a suspicious berm, a hot spot in a woodline, a muzzle flash, or a diesel plume behind masking terrain. If the round finds a target, it will be destroyed and an enemy location revealed. Such a capability for direct fire reconnaissance is currently lacking, but the potential benefit is clear.

The benefits of 'smart' tank munitions that we have described so far are those that increase a commander's options for target engagement. Since some of the potential uses are new, members of the U.S. Armor Force need to begin reorganizing the way they look at the battlefield. They need to consider how to best use the whole range of new capabilities. Tactics to successfully exploit these new weapons need to be developed and tested. Used correctly, 'smart' munitions can enhance opportunities for destroying the enemy and reduce the number of vulnerable situations for the firing tank.

Importantly, the addition of 'smart' tank munitions in the basic load may also reduce the ammunition resupply burden for tank units and should not increase the maintenance burden. There are several reasons for this. The obvious reason is, if accuracy is improved, fewer rounds are needed to defeat the same number of enemy targets. Fewer rounds required means fewer rounds resupplied. Additionally, if the direct-fire battle occurs at longer ranges and a unit's reaction time is increased, the possibility of pre-stocking ammunition is improved. This allows greater flexibility in planning ammunition resupply. Finally, since the use of 'smart' munitions provides overall tactical benefits, victory may be achieved more quickly. For example, if initial enemy echelons are decisively defeated, follow-on echelons may never be committed to battle. A drawn-out slugging match is avoided and fewer rounds are expended.

There definitely seems to be value for the Armor Force in adopting 'smart' tank munitions. They are not about to replace more traditional kinetic energy or HEAT rounds, however. One obvious factor is cost. As mentioned earlier, 'smart' tank munitions will be expensive. Traditional rounds are very effective for the close-in battle (2000 meters or less) and it does not make much sense to substitute an expensive 'smart' munition when a traditional round will do just as well. Also, traditional rounds have the advantage of being 'too dumb to fool.' A disadvantage to any 'smart' munition is that countermeasures are possible and likely. In a highly countermeasured environment, traditional ammunition will still be required. Therefore, some mix of 'smart' and traditional ammunition should make up the basic load. To design that basic load, however, requires that we understand the environments in which we expect to fight and the tactics that best use the mix of ammunition types. Only then will the full value of these new rounds be realized.

Tactical Scenarios for 'Smart' Tank Munitions

One gains an appreciation of the benefit that 'smart' tank munitions provide by looking at their use in typical battlefield situations. The final part of this article will compare defensive and offensive scenarios, with and without 'smart' tank munitions. As you read these simple scenarios, start wargaming them yourselves. Be critical of our analysis. Fight the battles out in your own head. Start considering the problems and opportunities that 'smart' munitions will present for you, both in your current position and in the positions you expect to hold throughout your career as a tanker. Most importantly, discuss 'smart' tank munition tactics with your fellow tankers. That is really the best way to get the ideas going.

Typically, the goal for a unit in the defense is to deny the enemy his objective or to delay him and upset his plans. If properly employed, use of 'smart' tank munitions can radically improve the chance of achieving these goals. Consider a typical situation; an armor company is conducting a defense in depth against an attacking motorized rifle or tank battalion. Currently, the defending tank company must wait until the enemy has closed to 2000 meters or so, before really effective direct fire can be brought to bear. The enemy vehicles are moving and maneuvering, making them difficult targets to hit. Additionally, they are moving in and out of masking terrain, thus making clear shots very difficult. By the time the enemy has closed enough for defensive, direct fires to be effective, the enemy is moving in assault formations and is beginning his artillery preparation of the defensive positions. Timing of the defensive battle now becomes very difficult. In less than a minute, the enemy will be 1500 meters away. If the defenders wait too long, they risk decisive engagement and will be unable to move to subsequent battle positions. Moving too soon risks effective engagement of the enemy and loss of the opportunity presented. Innumerable battles on the sands of the National Train-

ing Center have proven just how difficult it is to coordinate this kind of defensive battle.

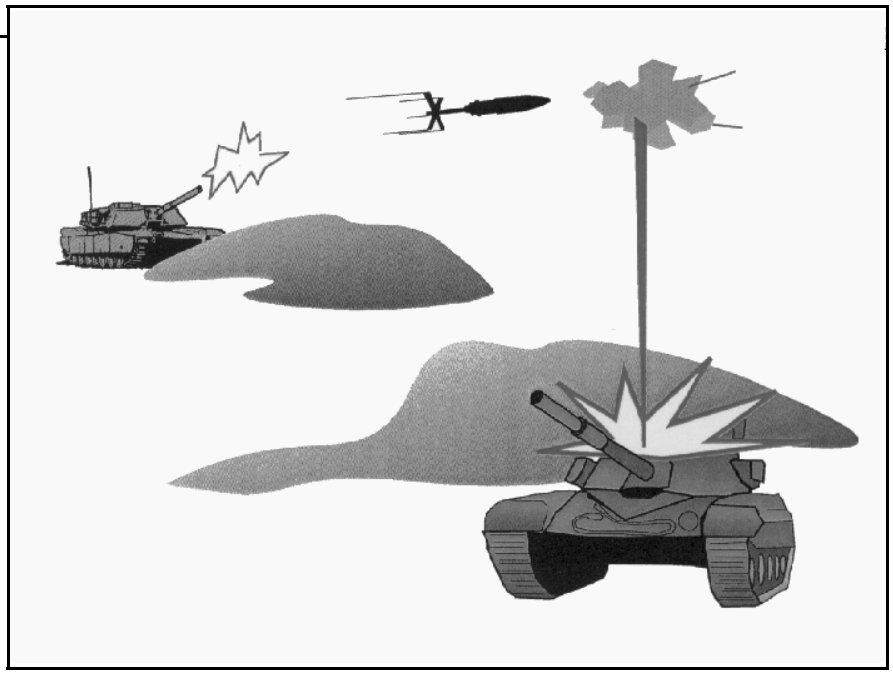
'Smart' tank munitions promise to alter this scenario significantly. By improving the effective range of the defending tanks, 'smart' rounds will open up the area of the battlefield that can be controlled by fire, thus increasing the decision time that the commander has to influence the battle. Additionally, 'smart' rounds greatly reduce the attacker's effectiveness in the use of masking terrain and evasive maneuver.

Consider the same defensive scenario when the defenders have 'smart' tank munitions in their basic load. With careful placement of the tanks, the defenders begin effective, direct fire on the enemy from as far as 4000 meters away. Evasive maneuvering by the enemy tanks proves ineffective against X-Rod. Masking terrain fails to ensure safety against the high flying STAFFs. As the enemy formation is engaged, its commander sees no alternative but to move into assault formation and call in artillery, even though he is still more than 3000 meters away. His attack slows and becomes confused.

The artillery preparation of his objective is no longer as effective, as it is not coordinated with the final assault. The defenders, out of effective range of the enemy tanks, can move to alternate positions with relative impunity. Because he has more time, the defending commander can more easily synchronize his fire and maneuver, ensuring that the attacking enemy is under constant fire, from a variety of positions. If needed, the commander can disengage before the enemy can effectively engage. Alternatively, the commander could continue to destroy the enemy at long range with 'smart' munitions, breaking up the attack, and finishing off those vehicles that manage to get closer, with traditional tank ammunition.

In either case, more enemy were engaged and destroyed because the number of engagement opportunities increased. Additionally, the vulnerability of the defenders was reduced as they engaged at longer range, with more effectively coordinated fires, and they had more time and better opportunities to move between alternate positions and shape the battle.

This is just one defensive scenario demonstrating the potential value of 'smart' tank munitions. The key point is that the defending commander's decision cycle is much longer because he can control so much more territory through fire. Additional value is obtained during a defensive combined arms effort. 'Smart' tank munitions will provide a defending commander a long-range, direct-fire weapon that can be combined with other long-range arms. Consider the effectiveness of a kill zone that is shaped by obstacles and contains fires from attack helicopters, cannon and missile artillery, guided missiles and direct fire tank munitions, yet is 4 kilometers from the nearest friendly position. Enemy formations could be shattered long before they could bring effective, direct fire to bear on the defenders.



The top-attack smart round is particularly effective against tanks masked by terrain.

As with the defensive scenarios, inclusion of 'smart' tank munitions in the basic load can provide new capabilities in offensive situations. It may be that the advantages brought to the offensive scenario are even more dramatic, since the traditional advantages of the defender are partially neutralized by 'smart' tank munitions. Some of the advantages that defending tanks enjoy include firing from dug-in or defiladed positions, firing from stationary positions, moving along reconned and masked routes and finally, choosing the ground from which to fight. While 'smart' tank munitions will not address the problem of who chooses the ground, they can even the balance in the other areas. Consider the following scenario.

A friendly armor company is conducting a deliberate attack against a dug-in tank platoon. A traditional scheme of maneuver requires moving the company to within 2000 meters of the objective. One platoon then overwatches the attack of the other two platoons. The defending enemy, firing from dug-in positions has the advantage of firing at tanks in the open, from stationary positions. The overwatching friendly platoon will have problems placing effective fires against long-range, defiladed targets, while the maneuvering tanks have problems firing on the move against defiladed targets. The attack may achieve its objective, but the cost is likely to be high.

Now, give the attacking company 'smart' tank munitions. From 4000 meters away, an overwatching platoon begins its search for targets on the objective. Peering through the tank's thermal viewers, one of the overwatching gunners spots a tell-tale plume of hot exhaust behind a berm. Before the attacking platoons even begin their movement forward, a STAFF round is launched toward the exhaust plume. The round's seeker finds a target and an explosively formed penetrator reduces the defending force by 25 percent before the attack has begun. The enemy platoon leader senses that there will be trouble and orders his remaining tanks to begin engagements at long range (2000 meters) and move often between alternate positions.

As the attacking platoons move out, a pair of enemy attack helicopters appear

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on the horizon. As they maneuver into position to launch their missiles, a tank in the overwatching platoon spots them and fires an X-Rod. The round easily sees the targets and maneuvers toward one of the helicopters. The long rod passes through the thin shell of the aircraft, causing only minor damage, but its expended rocket motor crashes into the side of the helicopter. As the damaged helicopter autorotates to the ground, the other helicopter pilot decides not to test fate and aborts his attack.

When the attacking tank platoons are 2000 meters from the objective, the three defending enemy tanks open fire. Because they are firing against maneuvering targets, their fire is not particularly effective. What they have done though, is to give away their positions. Some of the attacking tanks have 'smart' rounds in the chamber, as do the overwatching tanks. Without pausing, and despite traveling 30 miles per hour over rough terrain, the attackers let loose a barrage of guided, kinetic-energy and top-attack rounds at the defenders. Puffs of smoke identify projectiles whose rocket thrusters ignite to maneuver them against identified targets. Bright explosions above the ground mark the launching of EFPs against armored targets. Two more defenders are destroyed. The final defender is seen by the overwatching platoon as it moves towards an alternate position.

Two more STAFFs are fired. Hits to the enemy's turret and engine compartment ensure that the objective will be taken without further loss of friendly tanks.

Conclusion

In these simple scenarios we have attempted to illustrate the potential impact of 'smart' tank munitions. Because of their longer range, they will open the spacial parameters of armor units. The added range will also provide commanders more time to shape the battle. Additionally, by providing a moving tank the same hitting capability as a stationary tank, 'smart' tank munitions can speed up the tempo of battle. These are just some of the implications. Members of the Armor Force must begin considering all the tactical implications of 'smart' tank munitions now. New ideas must be explored, tested, and simulated. This new technology will open a whole new era for the U.S. Armor Force. Now is the time to start preparing for it.

Building Better "Bullets" - The OPM-TMAS Story

The charter for the Office of the Project Manager for Tank Main Armament Systems (OPM-TMAS) was approved by the Secretary of the Army in 1979. OPM-TMAS's original mission was for the development, acquisition and fielding of 105- and 120-mm tank lethality systems for the XM1 tank system. Under its original mission, the OPM-TMAS staff managed the development and subsequent acquisition of the 120-mm M256 cannon, now in service on the M1A1 and M1A2. They also provided the M774 and M833 105-mm kinetic energy rounds. Additionally, under its original charter, the personnel at OPM-TMAS managed the development and fielding of 120-mm tank ammunition, most significantly, the M829 kinetic energy round, the M830 HEAT round, and their equivalent training projectiles, the M865 and the M831. In the mid-eighties, OPM-TMAS became responsible for the Armament Enhancement Initiative (AEI). This program is an effort to leap ahead in tank fired, antiarmor munition's lethality. OPM-TMAS's successes to date, under the AEI, include the M900, the M829A1 and its follow-on, the M829A2, and the M830A1 multi-purpose round. AEI also includes the Smart, Target Activated, Fire and Forget (STAFF) round, which is one of the subjects of this article. In addition to tank ammunition, OPM-TMAS is charged with fire control development and several advanced projects in this area are on-going at this time. OPM-TMAS's current Project Manager is COL Richard Bregard. He is assisted by a core staff of 35 civilian and military personnel. For questions concerning this article or OPM-TMAS, contact MAJ Bruce Held, DSN 880-2615.